

State of Hawaii  
DEPARTMENT OF LAND AND NATURAL RESOURCES  
Division of Aquatic Resources  
Honolulu, Hawaii 96813

April 28, 2006

Board of Land  
and Natural Resources  
Honolulu, Hawaii

THE DIVISION OF AQUATIC RESOURCES REQUESTS BOARD OF LAND AND  
NATURAL RESOURCES (BLNR) AUTHORIZATION/APPROVAL TO ISSUE ONE  
(1) NORTHWESTERN HAWAIIAN ISLANDS (NWHI) RESEARCH, MONITORING  
AND EDUCATION PERMIT TO DR. BRIAN BOWEN OF THE HAWAII  
INSTITUTE OF MARINE BIOLOGY, FOR THE TAKE OF FISHES FOR GENETIC  
SAMPLING IN ORDER TO STUDY CORAL REEF CONNECTIVITY

Submitted herewith for your authorization and approval is a request for issuance of a NWHI Access Permit to Dr. Brian Bowen of the Hawaii Institute of Marine Biology (HIMB), University of Hawaii. The Research, Monitoring and Education Permit, described below, will allow activity to occur in the NWHI State marine Refuge (0-3 miles) waters surrounding Nihoa Island, French Frigate Shoals, and Gardner Pinnacles. The activities covered under this permit will occur from May 18 to June 11, 2006, from the support vessel Hi'ialakai. Ship details are provided with Item F-4.

Bowen will be conducting a genetic survey of reef fishes, intended to address the issue of population connectivity across the NWHI. He proposes to survey 22 species across the entire archipelago, using mtDNA sequencing technologies. The motivation for these studies is to resolve larval dispersal between reef habitats, to bolster the scientific foundations for conservation of the Northwest Hawaiian Islands. In particular, this research will provide an evaluation of the fundamental connections (or lack thereof) between isolated reef habitats in the NWHI. The level of isolation of fish populations within the Refuge is very important information for management purposes. This information can tell us, e.g., whether there is one stock of a particular fish species, or several, rarer, sub-stocks (or even "cryptic species" - new species of fish that are morphologically similar/identical to existing species). Obviously, management strategies will change dependent on whether fish populations of the NWHI are found to be isolated management units, or a single interactive metapopulation.

The proposed activities (below) are consistent with and support the purposes of the Refuge, primarily to better understand and manage the resources within the marine refuge.

Bowen and sub-permittees propose to take samples of reef fishes from Nihoa, FFS, and Gardner Pinnacles (see attached species list and sample sizes). Sampling will be accomplished primarily by pole spear. Samples will be analyzed genetically at the Hawaii

Institute of Marine Biology after the research cruise, as detailed in the Permit Application.

#### REVIEW PROCESS:

This permit application was received by the Division of Aquatic Resources on March 9, 2006. It was sent out for review and comment to the following scientific entities: Division of Aquatic Resources staff (5), Division of Forestry and Wildlife, Northwest Hawaiian Islands Reserve, and the United States Fish and Wildlife Service. Native Hawaiians from the Office of Hawaiian Affairs, and Kaho'olawe Island Reserve Commission were also consulted.

Comments received from the Scientific Community (DAR and the NWHI Reserve) are summarized as follows:

- 1) Two reviewers expressed concern at the scarcity of some target species, such as moray eels and some butterflyfish species
- 2) Concern was expressed at the lethal sampling method, and recommendation was made that rare or uncommon species be collected live and biopsied in the field
- 3) Samples should be shared with other researchers and preserved for possible use by future researchers
- 4) Concern was raised that sampling by pole spear might result in damage to live coral during the collection process
- 5) Bowen was asked to minimize his sample size and species list as much as possible

Comments received from a Native Hawaiian are summarized as follows:

1. There was concern for native Hawaiian intellectual property rights for new discoveries and the protection of the resources for their potential product developments.

#### RESPONSE:

A meeting of DAR staff and HIMB researchers was held on 12 April 2006 to address concerns, and a synopsis of the response to concerns raised is as follows:

- 1) Bowen amended his target species list by removing six species of concern, and reducing sampling sizes to the bare minimum that would provide adequate data. His revised sampling request is attached. He pointed out that his entire collection will result in the removal of less than 10 kg of biomass in a habitat with millions of kg of biomass.
- 2) Bowen agreed to sample non-lethally where possible, such as for fang blennies, which can be captured by SCUBA divers with hand-held nets
- 3) Bowen provided a list of five other researchers who will be sharing his fish samples, and agreed to preserving samples for future use
- 4) Bowen noted that his divers are required to follow a "blue water rule", which is that if one cannot see blue water behind the target fish, no shooting is allowed.

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Furthermore, no collecting at all is pursued in areas of Acropora tables or other fragile reef structures

- 5) The Guidelines for Submitting Permit Applications stipulates that, for all permits, the activity must be non-commercial and will not involve the sale of any organism, byproduct, or material collected. Furthermore, the Guidelines state that resources and samples are a public trust, and are not to be used for sale, patent, bioassay, or bio-prospecting, or for obtaining patents or intellectual property rights. This condition will be added to the Permit Terms and Conditions for this, and all future permits. This should address the concerns raised by the Native Hawaiian reviewer.

AMENDMENTS REQUESTED SUBSEQUENT TO APPLICATION SUBMISSION:

Bowen requested (in writing) on April 12, 2006 that three sub-permittees be added to his request: Drs. Randall Kosaki, Malia Rivera, and Jill Zamzow.

FINAL STAFF RECOMMENDATIONS:

- 1) Approve the take of fishes of the species, numbers, and locations indicated in the revised table (attached), with the conditions stipulated above.
- 2) Uncommon species must be live-captured, biopsied, and returned to the reef
- 3) Approve the addition of the requested sub-permittees

RECOMMENDATION:

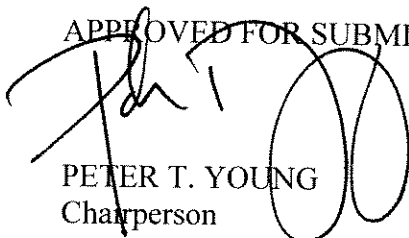
"That the Board authorize and approve, with stated conditions, a Research, Monitoring and Education Permit to Dr. Brian Bowen of the Hawaii Institute of Marine Biology, for activities and access within the State waters of the NWHI."

Respectfully submitted,



DAN POLHEMUS  
Administrator

APPROVED FOR SUBMITTAL



PETER T. YOUNG  
Chairperson

## APPENDIX 1

**State of Hawai'i  
DLNR  
Northwestern Hawaiian Islands State Marine  
Refuge  
Permit Application Form**

<i>For Office Use Only</i>
Permit No:
Expiration date:
Date Appl. Received: <u>3/9/06</u>
Appl. Fee received: <u>N/A</u>
NWHI Permit Review Committee date:
Board Hearing date:
Post to web date:

### Type of Permit

- ☒ I am applying for a **Research, Monitoring & Education** permit. (Complete and mail Application)
- ☒ This application is for a NEW project in the State Marine Refuge.
- ☐ This application is for an ANNUAL RENEWAL of a previously permitted project in the State Marine Refuge.
- ☐ I am applying for a permit for a **Native Hawaiian** permit. (Complete and mail Application)
- ☐ This application is for a NEW project in the State Marine Refuge.
- ☐ This application is for an ANNUAL RENEWAL of a previously permitted project in the State Marine Refuge.
- ☐ I am applying for a **Special Activity** permit. (Complete and mail Application)
- ☐ This application is for a NEW project in the State Marine Refuge.
- ☐ This application is for an ANNUAL RENEWAL of a previously permitted project in the State Marine Refuge.

Briefly describe **Special permit** activity:

When will the NWHI activity take place?

- ☒ **Summer** (May-July of 2006 (year)

Note: Permit request must be received before February 1st  
Specific dates of expedition May 18 - June 14, 2006

- ☐ **Fall** (August-November) of 2006 (year)

Note: Permit request must be received before May 1<sup>st</sup>  
Specific dates of expedition \_\_\_\_\_

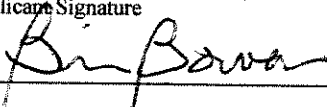
- ☐ **Other**

**NOTE: INCOMPLETE APPLICATIONS WILL NOT BE ACCEPTED**

**Please Send Permit Applications to:**

NWHI State Marine Refuge Permit Coordinator  
State of Hawai'i  
Department of Land and Natural Resources  
Division of Aquatic Resources  
1151 Punchbowl Street, Room 330  
Honolulu, Hawai'i 96813

**NWHI State Marine Refuge Permit Application**  
**See Appendix 2 for Application Instructions**

<b>Section A - Applicant Information</b>	
1. Project Leader (attach Project Leader's CV or resume) <input checked="" type="checkbox"/> CV attached <b>Bowen, Brian W</b> Name: Last, First, Middle Initial	Assistant researcher Title
2. Mailing Address (Street/PO Box, City, State, Zip) <b>Hawaii Institute of Marine Biology  P.O. Box 1346  Kaneohe HI 96744</b>	Telephone ( 808 ) 236-7426 Fax ( 808 ) 236-7443 Email Address <b>bbowen@hawaii.edu</b>
3. Affiliation (Institution/Agency/Organization) <b>University of Hawaii</b>	For graduate students, Major Professor 's Name & Telephone
4. Sub-Permittee/Assistant Names, Affiliations, and Contact Information <input type="checkbox"/> CV or resume attached <b>Luiz A. Rocha Ph.D., Matthew T. Craig Ph.D., Jeff Eble (graduate student)</b>	
5. Project Title <b>HIMB-NWHI Coral Reef Research Partnership: Connectivity of coral reef fishes</b>	
6. Applicant Signature 	7. Date (mm/dd/yyyy) <b>03/07/2006</b>

<b>Section B: Project Information</b>
8. (a) Project Location <input checked="" type="checkbox"/> NWHI State Marine Refuge (0-3 miles) waters surrounding: <input checked="" type="checkbox"/> Nihoa Island <input type="checkbox"/> Necker Island (Mokumanamana) <input checked="" type="checkbox"/> French Frigate Shoals <input type="checkbox"/> Laysan <input type="checkbox"/> Maro <input checked="" type="checkbox"/> Gardner Pinnacles <input type="checkbox"/> Lisianski Island, Neva Shoal <input type="checkbox"/> Pearl and Hermes Atoll <input type="checkbox"/> Kure Atoll, State Wildlife Refuge <input type="checkbox"/> Other NWHI location  Describe project location (include names, GPS coordinates, habitats, depths and attach maps, etc. as appropriate).  <b>48x see attached</b>

**(b) check all actions to be authorized:**

- ☒ Enter the NWHI Marine Refuge waters
- ☒ Take (harvest)                      ☒ Possess                      ☒ Transport (☒ Inter-island    ☐ Out-of-state)
- ☒ Catch                                      ☒ Kill                      ☐ Disturb    ☐ Observe
- ☐ Anchor                                      ☐ Land (go ashore)                      ☐ Archaeological research
- ☐ Interactions with Sea Turtles or Monk Seals    ☐ Interactions with Seabirds
- ☐ Interactions with Live Coral, Ark Shells or Pearl Oysters
- ☐ Interactions with Jacks, Grouper or Sharks
- ☐ Conduct Native Hawaiian religious and/or cultural activities
- ☐ Other activities \_\_\_\_\_

**(c) Collection of specimens – collecting activities (would apply to any activity):**

**Organisms or objects (List of species, if applicable, add additional sheets if necessary):**

Common name	Scientific name	No. & size of specimens	Collection Location(s)
See attached			

**(d) What will be done with the specimens after the project has ended?**

Specimens will be archived in tissue buffer, DNA will be stored in -80 degree freezer.

**(e) Will the organisms be kept alive after collection?**    ☐ yes    ☒ no

- Specific site/location \_\_\_\_\_
- Is it an open or closed system?                      ☐ open    ☐ closed
- Is there an outfall?                                      ☐ yes    ☐ no
- Will these organisms be housed with other organisms? If so, what are the other organisms?

(Please attach additional documentation as needed to complete the questions listed below)

9. Purpose/Need/Scope:
<ul style="list-style-type: none"> <li>This research is a genetic survey of reef fishes, designed to address the issue of population connectivity across the NWHI. We will survey 22 species across the entire archipelago, using mtDNA sequencing technology. See attached research statement.</li> </ul>
Describe how your proposed activities will help provide information or resources to fulfill the State Marine Refuge purpose and to reach the Refuge goals and objectives.
<ul style="list-style-type: none"> <li>The motivation for these population connectivity studies is to resolve larval dispersal between reef habitats, to bolster the scientific foundations for conservation of the Northwest Hawaiian Islands. See attached statement.</li> </ul>
<ul style="list-style-type: none"> <li>Describe context of this activity, include history of the science for these questions and background.</li> </ul> <p>The fundamental units of wildlife management are isolated stocks and ecosystems. The research will use advanced molecular technologies to resolve these units in the NWHI.</p>
<ul style="list-style-type: none"> <li>Explain the need for this activity and how it will help to enhance survival or recovery of refuge wildlife and habitats.</li> </ul> <p>See attached research statement.</p>
<ul style="list-style-type: none"> <li>Describe how your proposed project can help to better manage the State Marine Refuge.</li> </ul> <p>See attached research statement.</p>
10. Procedures (include equipment/materials)
Fish will be collected with polespears. See attached.
11. Funding sources (attach copies budget & funding sources).
Northwest Hawaiian Islands Coral Reef Ecosystem Reserve. See attached.
12. List all literature cited in this application as well as all other publications relevant to the proposed project.
See attached
13. What types of insurance do you have in place? (attach documentation)
<input checked="" type="checkbox"/> Wreck Removal <input checked="" type="checkbox"/> Pollution
14. What certifications/inspections do you have scheduled for your vessel? (attach documentation)
<input checked="" type="checkbox"/> Rat free <input type="checkbox"/> tender vessel <input type="checkbox"/> gear/equipment <input checked="" type="checkbox"/> Hull inspection <input checked="" type="checkbox"/> ballast water
15. Other permits (list and attach documentation of all other required Federal or State permits).
Permits from the U.S.F.W.S. and the NWHI Coral Reef Ecosystem Reserve are pending
16. Project's relationship to other research projects within the NWHI State Marine Refuge, National Wildlife Refuge, NWHI Coral Reef Ecosystem Reserve, or elsewhere.
See attached

**Section C: Logistics****17. Time Frame:**

Project Start Date

05/01/2005

Project Completion Date

12/31/2009

Dates actively inside the State Marine Refuge.

05/19/2006 - 05/31/2006

Personnel schedule in the State Marine Refuge (describe who will be where and when).

See attached

**18. Gear and Materials**☒ Dive equipment☐ Radio Isotopes☐ Collecting Equipment☐ Chemicals (specify types)**19. Fixed installations and instrumentation.**☐ Transect markers☐ Acoustic receivers☐ Other (specify)**20. Provide a time line for sample analysis, data analysis, write-up and publication of information.**

See attached

**21. Vessel Information:**Vessel Name Hi'ialakaiIMO Number 8835619Vessel Owner NOAAFlag USACaptain's Name CDR S. KuesterChief Scientist or Project Leader R. KosakiVessel Type R/VCall sign WTEYLength 224 ftGross tonnage 1,914Port of Embarkation HonoluluLast port vessel will have been at prior to this embarkation Am SamTotal Ballast Water Capacity: Volume 487 m3 Total number of tanks on ship 10Total Fuel Capacity: 228,642 Total number of fuel tanks on ship 15

Other fuel/chemicals to be carried on board and amounts:

See attached

Number of tenders/skiffs aboard and specific type of motors:

See attached

Does the vessel have the capability to hold sewage and grey-water? Describe in detail.

See attached

Does the vessel have a night-time light protocol for use in the NWHI? Describe in detail (attach additional pages as necessary)

See attached

On what workboats (tenders) will personnel, gear and materials be transported within the State Marine Refuge?

See attached

How will personnel, gear and materials be transported between ship and shore?

See attached

If applicable, how will personnel be transported between islands within any one atoll?

See attached





## University of Hawaii at Manoa

Brian Bowen, Assistant Researcher

**Hawaii Institute of Marine Biology**

P.O. Box 1346 • Coconut Island • Kaneohe, Hawaii 96744-1346

Phone: (808) 236-7401 • E-mail: [bbowen@hawaii.edu](mailto:bbowen@hawaii.edu) • Fax: (808) 236-7443

March 7, 2006

NWHI State Marine Refuge Permit Coordinator  
Department of Land and Natural Resources  
Division of Aquatic Resources  
1151 Punchbowl St. Room 330  
Honolulu HI 96813

Dear Permit Coordinator;

Please find attached a permit application to conduct research in the NWHI State Marine Refuge.

I realize that the deadline for this application has passed, and plead for an exception due to the new permit format, which was formulated this month.

In essence, the proposed research is to define connectivity among refuge habitats with advanced DNA technology. This will resolve the level of isolation between disjunct habitats, a valuable foundation for management of this irreplaceable resource.

Please let me know if you need additional information.

Sincerely,

Brian Bowen

# Northwestern Hawaiian Islands State Marine Refuge

## Permit Application Form

### Supplemental Information

Bowen, Brian W.

#### 8a. Project Location

Nihoa	23° 03' 39" North	161° 56' 07" West
French Frigate Shoals	23° 43' 51" North	166° 09' 54" West
Gardner Pinnacles	25° 21' 58" North	170° 31' 09" West

Our request is to operate from dive boats launched from the NOAA vessel Hi'ialakai, collecting specimens in 10-100 feet depth on coral reef habitat. Collections will be made with polespears, and will be spread across several adjacent reefs in order to minimize impact on ecosystem function.

#### 8c. Collection of Specimens

To assess population connectivity, we need samples of up to 30 specimens per location. Actual sample sizes will be lower as not all sampling goals will be met at all locations. Note we are requested fewer specimens at French Frigate Shoals because we have specimens of some species from previous research cruises, collected under U.S. F.W.S. permits.

Common name	Scientific name	No. & size	Location(s)
<b><u>Family Acanthuridae</u></b>			
Yellow tang	<i>Zebrasoma flavescens</i>	30 all sizes 20 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Brown surgeonfish	<i>Acanthurus nigrofusus</i>	30 all sizes 20 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Blue-lined surgeonfish	<i>Acanthurus nigroris</i>	30 all sizes 20 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Orangecheek surgeonfish	<i>Acanthurus olivaceus</i>	30 all sizes 20 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Goldring bristletooth	<i>Ctenochaetus strigosus</i>	30 all sizes 20 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
<b><u>Family Chaetodontidae</u></b>			
Oval butterflyfish	<i>Chaetodon lunulatus</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Milletseed butterflyfish	<i>Chaetodon miliaris</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles

Blueline butterflyfish	<i>Chaetodon fremblii</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Pebbled butterflyfish	<i>Chaetodon multicinctus</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
<b><u>Family Labridae</u></b>			
Ornate wrasse	<i>Halichoeres ornatissimus</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Yellowtail coris	<i>Coris gaimard</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Slow wrasse	<i>Coris venusta</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Surge wrasse	<i>Thalassoma purpureum</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Blacktail wrasse	<i>Thalassoma ballieui</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
<b><u>Family Blenniidae</u></b>			
Scarface blenny	<i>Cirripectes vanderbilti</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Fangblenny	<i>Plagiotremus goslinei</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
Fangblenny	<i>Plagiotremus ewaensis</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
<b><u>Family Priacanthidae</u></b>			
Bigeye	<i>Priacanthus meeki</i>	30 all sizes 15 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
<b><u>Family Lutjanidae</u></b>			
Blueline snapper (ta'ape)	<i>Lutjanus kasmira</i>	30 all sizes 30 all sizes 30 all sizes	Nihoa French Frigate Shoals Gardner Pinnacles
<b><u>Family Muraenidae</u></b>			
Snowflake moray	<i>Echidna nebulosa</i>	30 juveniles 30 juveniles 30 juveniles	Nihoa French Frigate Shoals Gardner Pinnacles
Zebra moray	<i>Gymnomuraena zebra</i>	30 juveniles 30 juveniles	Nihoa French Frigate Shoals

		30 juveniles	Gardner Pinnacles
Yellowfin moray	<i>Gymnothorax flavimarginatus</i>	30 juveniles	Nihoa
		30 juveniles	French Frigate Shoals
		30 juveniles	Gardner Pinnacles

## 9. Research Statement

This research is a genetic survey of reef fishes, designed to address the issue of population connectivity across the NWHI. We will survey 22 species across the entire archipelago, using mtDNA sequencing technology. With a few notable exceptions (e.g. Rivera et al. 2004) reef organisms have not been surveyed on this scale.

Reef fauna typically have a pelagic phase (eggs and larvae), which lasts 20-60 days, followed by settlement onto a reef where they remain through juvenile and adults stages. Long distance dispersal is accomplished almost exclusively during the pelagic larval phase. However, the geographic limits of such dispersal are uncertain (Bowen et al. 2006a). Recent research shows that effective dispersal of marine larvae can fall far short of their potential (Swearer et al. 2002). These findings set the stage for a methodical range-wide survey of reef faunas in the Hawaiian archipelago.

The primary motivation for this work is to define the level of isolation among reef communities in the Hawaiian archipelago. Advances in population genetics, especially coalescence theory, will greatly enhance our analysis, elucidating the history of reef organisms, including the effective population size, founder events, and patterns of collapse and recovery (Harpending et al. 1998, Beerli and Felsenstein 2001, Emerson et al. 2001).

To preserve biodiversity, it is important to know how it arises (Bowen et al. 2006b). While the main objective is to assess genetic connectivity among shallow reef habitats, a "value added" component is that we can assess the age and origin of Hawaiian fauna as well as the age and origins of populations on each island. A genealogical approach to relationships among mtDNA haplotypes, including statistical parsimony (Templeton et al. 1992, Clement et al. 2000) will indicate whether the closest relatives to the Hawaiian fauna lie predominantly to the West (Ogasawara Arch, Wake Island, or Marshall Islands) or to the South (Line Islands; Gosline 1955; Maragos and Jokiel 1986; Maragos et al. 2004). In these cases, populations of the widespread Indo-Pacific species will be compared to the Hawaiian endemic. The geographic source of the Hawaiian form (especially Hawaiian endemics) will be resolved with parsimony networks and phylogenetic tools (see Methods), and the age of colonization events will be estimated with the mtDNA molecular clock.

**Objectives:** The objective of this permit request is a genetic (mtDNA) survey fish species across the NWHI to assess the level of connectivity among isolated reef habitats. We will accomplish this with samples of up to 30 fish specimens/species/location. Each location is an atoll or reef such as French Frigate Shoals, and collections will be made at a low density of approximately 10 individuals per hectare. The target species are chosen to be abundant and widespread in the archipelago, easy to identify, and easy to collect. Every effort is made to minimize the impact of these collections on the natural communities.

**Management benefits:** These data will provide direct information on connectivity required for management, and can also detect cryptic endemic species and document the patterns and history of species entering the Hawaiian Archipelago. Furthermore, by documenting the pattern and magnitude of connectivity in a diverse set of fish taxa, we can determine if there are general patterns that can guide management decisions for understudied species. The genetic surveys of connectivity among reef habitats will substantially augment the scientific foundation for conservation measures. Specifically, this research will establish whether reef ecosystems of the NW Hawaiian Islands are isolated management units (as preliminary data indicate) or components of an interactive metapopulation. In the former case, each reef ecosystem will have to recover from environmental insults (whether human or natural) without significant

input from other reef ecosystems. A corresponding conservation mandate would be that each ecosystem is an independent management unit.

An ongoing debate about the NWHI is whether this is a series of relatively fragile (isolated) ecosystems, or whether it is a single robust ecosystem that can sustain extraction of resources. There is also a direct management concern about whether the NWHI serves as a source or a sink for the main Hawaiian Islands. The assays of population connectivity outlined here will go a long way towards settling these issues in a format that has statistical power and scientific credibility.

**Justification:** The proposed research is a multispecies approach to assess population connectivity among tropical reef habitats of the Hawaiian archipelago. The immediate motivation for this work is to bolster the scientific foundations for comprehensive protection and conservation of the native marine resources in the Northwest Hawaiian Islands. Connectivity studies are mandated by the National Marine Sanctuary Program in order to assist decision making and conservation programs, particularly in the placement of no-take zones. This information will also be critical to assessing the patterns and magnitude of connection between the no-take Hawaiian Islands NWR and the main Hawaiian Islands.

## **10. Methods**

The target species inhabit shallow reefs and are accessible via scuba dives to depths of less than 100 feet. Whenever possible, we sample non-lethally and remove a rice-grain sized piece of tissue (biopsy) to release the animal in the location from which it was collected. However, most specimens are lethally collected with pole spears.

On the proposed expedition, specimens will be collected at Nihoa, French Frigate Shoals, and Gardner pinnacles. These will be compared to specimens collected previously in the main Hawaiian Islands, French Frigate Shoals, Pearl and Hermes, Midway, and Kure Atolls.

Statistical rigor requires a minimum sample size of 25 individuals per location. In studies examining the statistical power for inferring connectivity based on molecular tools, Ruzzante (1998) showed that sample sizes of less than 30-50 had significant bias and could often be misleading. Therefore, in the interest of maintaining statistical rigor while minimizing the number of samples collected, our target sample size is 30/location for fish species.

Given that we have two to five days of collecting per location, our goal will be to focus on the species that can be collected rapidly, safely, and without likely impact on the population of the target species. Likely collection sites at each location have been identified by Randy Kosaki, and were also scouted by our researchers on the May 2005 cruise. However, we require some flexibility because our priorities for collecting at specific locations will be dictated in part by unpredictable field conditions and weather. As noted elsewhere, we are only collecting specimens from species that occur in high abundance: i.e., at least thousands per location. Also the collections will be spread across an area of approximately five hectares (we will collect a maximum of 10 individuals per hectare), so that no one site will be at risk of being depleted.

The primary lab methodology in this study will be sequencing of mtDNA cytochrome genes. In most species, a segment of approximately 800 base pairs of the mtDNA cytochrome b or cytochrome oxidase gene will be amplified and sequenced following protocols used daily in our laboratory. DNA sequences will be generated with an ABI 3100 automated DNA sequencer in our lab. Genomic DNA aliquots will be maintained in long-term storage at HIMB so that the genetic material collected will be available for future studies.

DNA sequence variation will be summarized with standard diversity indices and with an analysis of molecular variance (AMOVA) using ARLEQUIN vers. 2 (Schneider et al. 2000). Coalescence approaches will be used to infer population histories, including growth rates, effective population size and age of founding populations. Phylogenetic methods will include neighbor joining and maximum likelihood algorithms in PAUP version 4.0 (Swofford 2002). Population separations will be defined with using  $F_{st}$

values and the maximum likelihood approach of MIGRATE vers. 1.7.3 (Beerli and Felsenstein 2001). The key innovation in MIGRATE (relative to conventional Nm estimates) is that it estimates asymmetric migration: cases where one region is a source and another is a recipient. The utility of this information for resolving dispersal pathways is readily apparent. Population connectivity across the NWHI is an essential foundation for prudent management and the establishment of no-take zones throughout the entire Hawaiian Archipelago and beyond. These data are also essential to the on-going debate on whether the NWHI serve as a source or sink for fisheries species in the Main Hawaiian Islands.

## 11. Funding Sources

The budget below includes our work and that of other related projects using other personnel

### Budget for 2006 HIMB – NWHI CRER Cooperative agreement

*Biodiversity Characterization of NWHI in terms of spatial connectivity*

#### Personnel

		Position	FTE	12 mo Sal	Actual Salary	fringe .3867	
Matt Craig	Bottomfish	Asst. Res	1	50,000	50,000	19335	69,335
Scott Godwin	Invertebrates	GRA	0.5	56,000	28,000	4200	32,200
Luis Rocha	Endemic Reef Fish	Asst. Res	1	50,000	50,000	19335	69,335
Iliana Baums	Coral Species	Asst. Res	1	50,000	50000	19335	69335
Steve Karl	Plankton, Picoplankton	Asst. Res	1	50,000	50000	19335	69,335
					228,000	81540	309,540
Supplies	Biochemicals	10000					
	Plastics	5000					
	Sequencing	20000					
	Sample Collection	2522					
	Sequencer Service	21709					
		59231					59231
Travel	Meetings/perdiem	10,000					10,000
Publications	page charges, videos	5,000					5,000
Direct Costs							383,771
Modified DC	(36.3% of total costs minus equipment and Stipend)						383,771
Indirect Costs							139308.8
Total Costs for Objective							523,080

## 12. Literature Cited

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- Toonen, R.J. 2001. Molecular Genetic Analysis of Recruitment and Dispersal in the Intertidal Porcelain Crab, *Petrolisthes cinctipes*. Ph.D. Dissertation, Center for Population Biology, Section of Evolution and Ecology, University of California, Davis, CA. 325 pp.

### 13 - What types of insurance do you have in place?

NOAA Ship HI'IALAKAI is a U.S. Government-owned and -operated research vessel and is self-insured by the U.S. Government. The research team is insured through the University of Hawaii.

### 14 - What certifications/inspections do you have scheduled for your vessel?

- Rat Free (scheduled with U.S. Dept. of Health and Human Services for April 2006)
- Hull Inspection (scheduled with Hawaii Institute of Marine Biology biologists (normally Scott Godwin) prior to projects working in the Northwestern Hawaiian Islands (NWHI) to ensure no nuisance algae or other fouling species are transported to the NWHI.
- Ballast water information is transmitted to USCG as required by CFR Title 33, Vol. 2, Parts 151.1500 to 199; IMO Resolution A.868(20); and USCG COMDTPUB P16700.4

### 16. Relationship to other research projects within the NWHI State Marine Refuge, National Wildlife Refuge, NWHI Coral Reef Ecosystem Reserve, or elsewhere.

This research is integrated with a parallel study of genetic connectivity in reef invertebrates by Robert Toonen. Both studies will survey the reefs of the NWHI and main Hawaiian Islands. Furthermore, the P.I. (Bowen) has an NSF grant to survey the same fish species across the Indo-Pacific. This will provide a yardstick for interpretation of results in the NWHI, and will resolve the source of natural colonizers that enhance the biodiversity of NWHI coral reefs.

#### **17. Proposed personnel/vessel schedule for the Hi'ialakai May June 2006.**

May 18-19	Honolulu to Nihoa
May 20-23	Nihoa collections
May 24-28	French Frigate Shoals collections
May 29-30	Gardner Pinnacles collections
May 31 – June 14	Collections at Johnston Atoll, outside the state reserve

All dates are subject to minor adjustments due to weather and ocean conditions

#### **20. Time line for sample analysis, data analysis, write-up and publication of information**

May 2006 – December 2007	Collection of specimens
June 2006 – December 2008	DNA isolation and sequencing
January 2007 – July 2008	Data analysis and report preparation
July 2007 – December 2009	Publication of at least five peer-reviewed papers

#### **21. Vessel Information**

**Other fuel/chemicals to be carried on board and amounts:** gasoline – as much as 700 U.S. gal.; lube oil – as much as 10,442 U.S. gal.; numerous other industrial and household chemicals used to operate a 224-foot research vessel

#### **Number of tenders/skiffs aboard and specific type of motors:**

Ship's own tenders -	1 each 10 m AMBAR Marine jet boat with Yanmar 370-hp, Diesel inboard engine
	1 each 8 m AMBAR Marine jet boat with Yanmar 315-hp, Diesel inboard engine
	2 each 17.5 ft Zodiac inflatable boats, each with one Honda 50-hp, 4-stroke, outboard gasoline engine
	1 each 19 ft AMBAR Marine rescue boat with Honda 115-hp, 4-stroke, outboard gasoline engine
Program-provided tenders -	19' Boston Whaler with 135 hp Honda four-stroke outboard

**Does the vessel have the capability to hold sewage and grey-water? Describe in detail.** The ship has a 4,000 U.S. gal Collection Holding Tank for sewage and grey water. In those waters where effluent may NOT be discharged, sewage and grey water are held in this tank until the ship is in waters where sewage and grey water may be discharged. The ship has a U.S. Coast Guard-approved Marine Sanitation Device (Omnipure model MSD 12 MC) which is used to treat sewage and grey water in those waters where effluent may be discharged.

**Does the vessel have a night-time light protocol for use in the NWHI? Describe in detail.** Navigation lights are on 24-hours/day. Work lights are put on at night only when conducting CTD operations. Weather decks are not illuminated at night.

**On what workboats (tenders) will personnel, gear and materials be transported within the State Marine Refuge?** - Personnel, gear and materials may be transported within the State Marine Refuge by the ship or any of the 5 ship's small boats listed above or by the program-provided small boat listed above.



**How will personnel, gear and materials be transported between ship and shore?** – Personnel, gear and materials may be transported between ship and shore by any of the 5 ship's small boats listed above or by the program-provided small boat listed above.

**If applicable, how will personnel be transported between islands within any one atoll?** -Personnel may be transported between islands within any one atoll by any of the 5 ship's small boats listed above or by the program-provided small boat listed above.

February 2006

**CURRICULUM VITAE**  
**BRIAN WILLIAM BOWEN**

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office: 808-236-7426  
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**Birthdate** May 18, 1957

**Family Status** Married: RuthEllen Klinger Bowen  
Two offspring: Nichole Veronica Bowen and Tamaria Ruth Bowen

<b>Education</b>	1980	Bachelor of Science, Biology, Providence College Advisor: Dr. Eugene Donahue
	1987	Master of Science, Marine Biology, College of William and Mary Advisor: Dr. John A. Musick
	1992	Doctor of Philosophy, Genetics, University of Georgia Advisor: Dr. John C. Avise

## Thesis Titles

Bowen, B.W. 1987. Population structure of the white perch, *Morone americana*, in lower Chesapeake Bay. M.S. thesis, College of William and Mary, Williamsburg VA.  
Bowen, B.W. 1992. Evolutionary genetics and natural history of marine turtles. Ph.D. dissertation, Univ. of Georgia, Athens.

## Professional Experience

Year	Experience
1981	Appalachian Trail, walked 2140 miles from Georgia to Maine
1983-85	Marine Turtle Stranding Network, Virginia
1984	Groundfish Survey, National Marine Fisheries Service
1984-85	Chesapeake Bay Monthly Trawl Surveys
1986-2004	18 international expeditions to collect samples of sea turtles and fishes
1992-97	Established and directed the Conservation Genetics Core in the Biotechnology Program at University of Florida
1994	Organized a conservation genetics workshop for biologists from developing nations (February 1994), funded by the U.S. Agency for International Development and the National Science Foundation.
1994	Organized a colloquium, Phylogeography of the Testudines, for the annual meeting of the Society for Study of Amphibians and Reptiles (July 1994)
1994-96	National Science Foundation Panelist: Conservation and Restoration Biology.
1995	Organized and convened the International Symposium on Conservation Genetics of Marine Turtles, with W.W. Witzell (September 1995)
1996	Workshop on Endangerment and Extinction in the Sea, organized by Elliot Norse, Center for Marine Conservation, Washington D.C.
1997-2002	Assistant Professor, Dept. of Fisheries and Aquatic Sciences, Univ. of Florida

- 1997-2004      Lecturer in short course organized by Stephen O'Brien: Recent Advances in Conservation Genetics, Smithsonian/Natl. Zoo
- 1998              New graduate course: Marine Phylogeography
- 1999              National Science Foundation Panelist: Biological Oceanography
- 1999              Marine Mammal Molecular I.D. Workshop, La Jolla, CA (June 1999)
- 2000              Organized a colloquium, Taxonomic status of the Black Turtle, for the annual meeting Sea Turtle Biology and Conservation, Orlando, FL
- 2000-2002      Annual expeditions to Bahamas with Stephen Karl to survey reef organisms, using the Florida research vessels Suncoaster and Bellows
- 2003-present    Expeditions to collect reef fishes at Christmas Island, American Samoa, Okinawa, NW Hawaiian Island, and elsewhere

#### **Graduate Students and Post-Doctoral Researchers**

##### M.S. Program

Joseph Roman (1998), Jeff Colborn (1999), Andrew Muss (1999), Alicia Francisco (2001), Jeff Eble (current)

##### Ph.D. Program

Angelica Garcia-Rodriguez (2000), Luiz Rocha (2003), Jennifer Schultz (current), Tonatuih Trejo (current), Michelle Gaither (current)

##### Post-Doctoral

Matthew Craig (current)  
Luiz Rocha (current)

#### **Professional Societies**

American Association for the Advancement of Science  
American Society of Ichthyologists and Herpetologists  
American Genetics Association  
International Biogeography Society  
International Society for Reef Studies  
Society for Conservation Biology  
Society for the Study of Evolution

#### **Professional Affiliations**

Fellow, American Association for the Advancement of Science  
Graduate Faculty, Dept. of Zoology, University of Hawaii  
Graduate Faculty, Ecology, Evolution, and Conservation Biology Program (EECB), Univ. of Hawaii

#### **Advisory Positions**

1994-present      IUCN Species Survival Commission, Marine Turtle Specialist  
1994-2000          Conservation Committee, Soc. Study of Amphibians and Reptiles  
1998-present      Fundacao Pro-TAMAR (Brazil) Ad-Hoc Consultants Committee  
2000-2002          Lab for Conservation Genetics, Max Planck Inst., Scientific advisor  
2001-2002          Steering Committee, North Atlantic Biogeography Project  
2005-present      Research Advisory Council, NW Hawaiian Islands Marine Sanctuary

#### **Editorial Positions**

1993-1999          *Genetica*, Associate Editor  
1996-2004          *Herpetological Review*, Associate Editor  
1998-2000          *Evolution*, Associate Editor  
2000-present      *Molecular Ecology*, Editorial Review Board  
2003-present      *Journal of Heredity*, Associate Editor

## Grants and Contracts

1987-89	National Geographic Society Research Grant: Population structure of the green turtle, <i>Chelonia mydas</i> (co-P.I.; \$17,000)
1989-91	National Science Foundation Diss. Improve. Grant: Evolutionary history of the green turtle, <i>Chelonia mydas</i> (co-P.I.; \$12,000)
1992-94	U.S. Fish and Wildlife Service. MtDNA analysis of hawksbill turtle populations in the Caribbean region (co-P.I.; \$40,000)
1993-95	U.S. Fish and Wildlife Service. Genetic analysis of sea turtle populations in the western Atlantic Ocean with emphasis on the southeast United States (P.I.; \$20,000)
1993-96	National Science Foundation: Population structure and conservation genetics of marine turtles (P.I.; \$121,000)
1993-94	U.S. Agency for International Development: Conservation genetics workshop for biologists from developing nations (P.I.; \$64,000)
1994-96	U.S. Fish and Wildlife Service: Conservation genetics, population structure and phylogeography of the alligator snapping turtle (P.I.; \$5,000)
1994-97	National Science Foundation: Global biogeography of coastal marine fishes: <i>Sardinops</i> and <i>Engraulis</i> (P.I.; \$36,000)
1995-96	U.S. Fish and Wildlife Service: Evolutionary distinctiveness of the pallid, shovelnose, and Alabama sturgeon ( <i>Scaphirhynchus</i> spp.) (co-P.I.; \$4,000)
1995-96	Florida Game and Fresh Water Fish Comm.: Genetic tools for forensic identification of meat and byproducts from the alligator snapping turtle ( <i>Macrolemys temminckii</i> ) (P.I.; \$5,000)
1995-96	National Marine Fisheries Service: Population structure of hawksbill turtles (P.I.; \$20,000)
1996-97	Florida Dept. of Environ. Protection: Phylogeography of bonefish ( <i>Albula</i> spp.) in Florida waters: how many populations and how many species? (P.I.; \$30,000)
1996-98	National Biological Service: Population structure of marine turtles in the southeastern U.S. (P.I.; \$67,000)
1997-99	National Biological Service, Conservation genetics of the timber rattlesnake, <i>Crotalus horridus</i> (P.I.; \$15,000)
1997-98	Florida Dept. Environ. Protection: Origin of marine turtles in Florida Bay (P.I.; \$10,000)
1997-98	Georgia Dept. of Natural Resources: Origin of loggerhead turtles stranded on the Georgia coast (P.I.; \$9,000)
1998-00	National Science Foundation: Population structure and biodiversity of Atlantic Reef Fishes (P.I.; 147,000)
1998-99	National Marine Fisheries Service; Genetic identities of loggerhead turtles stranded in the Southeast U.S. (P.I.; \$98, 952)
1998	Turner Foundation, through Archie Carr Center For Sea Turtle Research; Innovative Solutions In Marine Turtle Conservation (co-P.I.; \$20,000)
1998	Royal Caribbean Foundation; Sea turtle conservation (co-P.I.; \$50,000)
1998	Florida Dept. of Environmental Protection; <i>Albula</i> spp. differentiation in the Florida keys (P.I.; \$14,970)
1999	Georgia Dept of Natural Resources; Temporal variation in loggerhead turtle strandings from Georgia (P.I.; \$9,600)
1999	National Marine Fisheries Service; Genetic identity of juvenile loggerhead turtles captured at the St. Lucie power plant (P.I.; \$6,200)
1999	Disney Conservation Fund; Identification of Hybrid sea turtle hatchlings from the Archie Carr National Wildlife Refuge (co-P.I.; \$1,500)
1999	Disney Conservation Fund; Origin and population structure of juvenile green turtles ( <i>Chelonia mydas</i> ) from two Florida developmental habitats as determined by mtDNA markers (co-P.I.; \$20,000)
1999-00	Florida Marine Research Institute; Ecology and systematics of bonefish ( <i>Albula</i> spp.) in Florida waters (P.I.; \$44,100)
1999-01	National Marine Fisheries Service; Identification of loggerhead turtle, <i>Caretta caretta</i> , stock structure in the southeastern U.S. and adjacent regions using nuclear DNA markers (P.I.; \$80,476)

2001-03	Department of Agriculture; Genetic issues in hard clam aquaculture (P.I.; \$175,149)
2002-05	National Marine Fisheries Service; Genetic analysis of wahoo, <i>Acanthocybium solandri</i> , stock structure in the western Atlantic and Gulf of Mexico by means of nuclear and mitochondrial markers. (co-P.I.; \$165,276)
2003-04	National Marine Fisheries Service; Population genetic analysis of loggerhead sea turtle (P.I.; \$8,450)
2003-04	Hawaii Sea Grant Program; Genetic partitions and stock structure in Hawaiian opihi (Gastropoda: <i>Cellana</i> sp.) (P.I.; \$9,992)
2004-05	Hawaii Sea Grant Program; Movement patterns and genetic population structure of the whitetip reef shark ( <i>Triaenodon obesus</i> ) (P.I.; \$8,785)
2004-05	NOAA National Ocean Service; Isolation of Monk Seal microsatellite loci (co-P.I.; \$20,000)
2005-07	Hawaii Sea Grant Program; Genetic stock resolution in deep water snappers Ehu ( <i>Etelis carbunculus</i> ) and Onaga ( <i>Etelis coruscans</i> ) (P.I.; \$38,540)
2005-07	Hawaii Sea Grant Program; Stock structure in Hawaiian opihi (Gastropoda: <i>Cellana</i> spp.) (co-P.I.; \$38,540)
2005-08	National Science Foundation; Phylogeography of Indo-Pacific reef fishes (P.I.; \$510,000).
2005-06	National Marine Fisheries Service; Stock structure in deepwater snappers (P.I.; \$50,000)
2005-07	Northwest Hawaii Coral Reef Ecosystem Reserve; HIMB cooperative research (Co-P.I.: \$184,000/year my share of 1.5 million/year)
2005-2006	Hawaii Coral Reef Initiative; Phylogeography of Hawaiian Yellow Tang ( <i>Zebrasoma flavescens</i> ) (P.I.; \$59,800)

#### Awards

1990	American Society of Ichthyologists and Herpetologists, Stoye award for best student paper in herpetology
1991	Annual Marine Turtle Symposium, award for best student paper
1992	University of Georgia, Charles C. Anderson Memorial Award for research excellence in a dissertation thesis

#### Invited Presentations

1991	Southwest Fisheries Science Center, La Jolla CA
1992	Archie Carr Center for Sea Turtle Research, University of Florida National Marine Fisheries Service, Charleston Lab, Charleston SC Society for the Study of Amphibians and Reptiles, Annual Meeting, Hopkins Marine Lab, Stanford University, Pacific Grove CA CINVESTAV Graduate Research Institute, Merida, Yucatan, Mexico
1993	Drexel University, Philadelphia PA University of Central Florida, Orlando FL Louisiana State University, Baton Rouge LA Annual Interuniversity Congress on Marine Turtles, Mazatlan, Mexico
1994	Second World Congress of Herpetology, Adelaide, Australia Society for the Study of Evolution, annual meeting, Athens GA Symposium on Molecular Genetics of Marine Mammals, La Jolla CA
1995	American Assn. for Advancement of Science, annual meeting, Atlanta GA University of Vermont, Burlington VT Society for Study of Amphibians and Reptiles, annual meeting, Boone NC
1996	Western Society of Naturalists, annual meeting, Seattle WA Crocodilian DNA Workshop, Univ. of South Carolina, Columbia SC Florida Academy of Sciences, annual meeting, Melbourne FL University of California, Santa Cruz CA American Genetics Association, annual meeting, Athens GA University of South Florida, St. Petersburg, FL Atwood Memorial Lecture, University of Toronto, Ontario, Canada Dickinson Memorial Lecture, University of Richmond, Richmond, VA
1997	National Shellfish Association, annual meeting, Gulf Coast FL

- 1998 Gulf Coast Research Lab, Ocean Springs, MS  
Florida Wildlife Rehabilitators Association, Live Oak, FL  
Southampton University, Long Island, NY  
Keynote address, Annual Symposium on Sea Turtle Biology and Conservation, Mazatlan, Mexico  
Society for Study of Amphibian and Reptiles, annual meeting, Guelph, Canada  
Universidade Federal da Paraíba, João Pessoa, Brazil  
TAMAR Sea Turtle Station, Isla Fernando de Noronha, Brazil  
Duke University, Durham, NC  
Keynote address, Ninth Annual Meeting of the Japanese Sea Turtle Society, Yagushima, Japan
- 1999 University of South Florida, Tampa, FL  
Universite Laval, Quebec City, Canada  
Marine Mammal Molecular Identification Workshop, La Jolla, CA  
International Seminar on the Biology and Conservation of Sea Turtles, Santa Marta, Colombia  
Centre d'Etude et de Decouverte des Tortue Marines, Reunion Is., French Indian Ocean Territory
- 2000 University of South Carolina, Columbia, SC  
Sea Turtle Biology and Conservation, annual meeting, Orlando, FL  
Whitney Marine Lab, Volusia, FL  
College of Veterinary Medicine, Univ. of Florida  
Society for Conservation Biology, annual meeting, Missoula, MT  
College of Charleston, Charleston SC
- 2001 Wheaton College, Norton, MA  
Whitney Marine Lab, Volusia, FL  
Keynote address, FECES 9<sup>th</sup> Annual Meeting, Ordway, FL  
University of South Carolina, Columbia, SC  
University of New Orleans, LA
- 2002 Montana State University, Missoula, MT  
McGill University, Montreal, Quebec, Canada  
Univ. of Southern California, Los Angeles, CA  
Univ. of Hawaii, Honolulu, HI  
National Conservation Training Center, Shepherdstown, WV  
Florida Atlantic University, Boca Raton, FL
- 2003 Annual Hawaii Conservation Conference, Honolulu, HI  
International Biogeography Society, inaugural meeting, Mesquite, NV  
Dept. of Zoology, University of Hawaii, Manoa HI
- 2004 International Coral Reef Symposium, Okinawa, Japan  
Dept. of Biology, University of Hawaii, Hilo HI  
American Samoa Community College, Pago, Pago, Am. Samoa
- 2005 Smithsonian Tropical Research Institute, Bocas del Toro, Panama

### Scientific Publications

- Bowen, B.W., A. B. Meylan, and J.C. Avise. 1989. An odyssey of the green sea turtle, *Chelonia mydas*: Ascension Island revisited. *Proc. Natl. Acad. Sci. USA* 86:573-576.
- Avise, J.C., B.W. Bowen and T. Lamb. 1989. DNA fingerprints from hypervariable mitochondrial genotypes. *Mol. Biol. Evol.* 6:258-269.
- Bowen, B.W. and J.C. Avise. 1990. The genetic structure of Atlantic and Gulf of Mexico populations of sea bass, menhaden, and sturgeon: the influence of zoogeographic factors and life history patterns. *Marine Biology* 107:371-381.
- Meylan, A.B., B.W. Bowen and J.C. Avise. 1990. A genetic test of the natal homing versus social facilitation models for green turtle migration. *Science* 248:724-727.
- Bowen, B.W., A.B. Meylan, and J.C. Avise. 1991. Evolutionary distinctiveness of the endangered Kemp's ridley. *Nature* 352:709-711.
- Avise, J.C., B.W. Bowen, E. Bermingham, A.B. Meylan, and T. Lamb. 1992. Mitochondrial DNA evolution at a turtle's pace: evidence for low genetic variability and reduced microevolutionary rate in the Testudines. *Mol. Biol. Evol.* 9: 457-473.

- Bowen, B.W., A.B. Meylan, J.P. Ross, C.J. Limpus, G.H. Balazs and J.C. Avise. 1992. Global population structure and natural history of the green turtle (*Chelonia mydas*) in terms of matriarchal phylogeny. *Evolution* 46: 865-881.
- Karl, S.A., B.W. Bowen, and J.C. Avise. 1992. Global population structure and male-mediated gene flow in the green turtle (*Chelonia mydas*): RFLP analysis of anonymous nuclear DNA regions. *Genetics* 131:163-173.
- Bowen, B.W., W.S. Nelson, and J.C. Avise. 1993. A molecular phylogeny for marine turtles: trait mapping, rate assessment, and conservation relevance. *Proc. Natl. Acad. Sci. USA* 90: 5574-5577.
- Bowen, B.W., J.C. Avise, J.I. Richardson, A.B. Meylan, D. Margaritoulis, and S. Hopkins-Murphy. 1993. Population structure of the loggerhead turtle (*Caretta caretta*) in the northwest Atlantic Ocean and Mediterranean Sea. *Conservation Biology* 7:834-844.
- Laurent, L., J. Lescure, L. Excoffier, B.W. Bowen, M. Domingo, M. Hadjichristophorou, L. Kornaraki, and G. Trabuchet. 1993. Genetic relationships between Mediterranean and Atlantic populations of loggerhead turtle *Caretta caretta* with a mitochondrial marker. *Comptes Rendus de l'Academie des Sciences, Paris, Sciences de la vie* 316:1233-1239.
- Allard, M.W., M.M. Miyamoto, K.A. Bjorndal, A.B. Bolten, and B.W. Bowen. 1994. Support for natal homing in green turtles from mitochondrial DNA sequences. *Copeia* 1994:34-41.
- Ferl, R.J., G. Lu, and B.W. Bowen. 1994. Evolutionary implications of the family of 14-3-3 brain protein homologs in *Arabidopsis thaliana*. *Genetica* 92:129-138.
- Encalada, S.E., S. Eckert, and B.W. Bowen. 1994. Forensic applications of mitochondrial DNA markers: origin of a confiscated green turtle. *Marine Turtle Newsletter* 66:1-3.
- Avise, J.C. and B.W. Bowen. 1994. Investigating sea turtle migration using DNA markers. *Current Opinion in Genetics and Development* 4:882-886.
- Bowen, B.W., T.A. Conant, and S.R. Hopkins-Murphy. 1994. Where are they now? The Kemp's ridley headstart project. *Conservation Biology* 8:853-856.
- Bowen, B.W., N. Kamezaki, C.J. Limpus, G.H. Hughes, A.B. Meylan and J.C. Avise. 1994. Global phylogeography of the loggerhead turtle (*Caretta caretta*) as indicated by mitochondrial DNA haplotypes. *Evolution* 48:1820-1828.
- Bowen, B.W., F.A. Abreu-Grobois, G.H. Balazs, N. Kamezaki, C.J. Limpus, and R.J. Ferl. 1995. Trans-Pacific migrations of the loggerhead sea turtle demonstrated with mitochondrial DNA markers. *Proc. Natl. Acad. Sci. USA* 92:3731-3734.
- Bowen, B.W. 1995. Tracking marine turtles with genetic markers; voyages of the ancient mariners. *BioScience* 45:528-534.
- Bowen, B.W. 1995. Molecular genetic studies of marine turtles. Pp. 585-588 *In* *Biology and Conservation of Sea Turtles*, Second Edition, K. Bjorndal (ed.) Smithsonian Institution Press, Washington, D.C.
- Bowen, B.W. and J.C. Avise. 1995. Conservation genetics of marine turtles. Pp. 190-237 *In* *Conservation Genetics: Case Histories from Nature*, J.C. Avise and J.L. Hamrick (eds). Chapman and Hall, NY.
- Karl, S.A., B.W. Bowen, and J.C. Avise. 1995. Hybridization among the ancient mariners: identification and characterization of marine turtle hybrids with molecular genetic assays. *J. of Heredity* 86:262-268.
- Sears, C.J., B.W. Bowen, R.W. Chapman, S.B. Galloway, S.R. Hopkins-Murphy, and C.M. Woodley. 1995. Demographic composition of the juvenile loggerhead sea turtle (*Caretta caretta*) feeding population off Charleston, South Carolina: evidence from mitochondrial DNA markers. *Marine Biology* 123:869-874.
- Bass, A.L., D.A. Good, K.A. Bjorndal, J.I. Richardson, Z.-M. Hillis, J.A. Horrocks, and B.W. Bowen. 1996. Testing models of female migratory behavior and population structure in the Caribbean hawksbill turtle, *Eretmochelys imbricata*, with mtDNA control region sequences. *Molecular Ecology* 5:321-328.
- Bowen, B.W., A.L. Bass, A. Garcia, C. E. Diez, R. van Dam, A. Bolten, K.A. Bjorndal, M.M. Miyamoto and R.J. Ferl. 1996. The origin of hawksbill turtles in a Caribbean feeding area as indicated by genetic markers. *Ecological Applications* 6:566-572.
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Table 1

<b>Common name</b>	<b>Scientific name</b>	<b>No. &amp; size Location(s)</b>
<b>Family Acanthuridae</b>		
Yellow tang	<i>Zebrasoma flavescens</i>	30 all sizes Nihoa 6 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
Brown surgeonfish	<i>Acanthurus nigrofuscus</i>	30 all sizes Nihoa 30 all sizes Gardner Pinnacles
Blue-lined surgeonfish	<i>Acanthurus nigroris</i>	30 all sizes Nihoa 16 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
Orangecheek surgeonfish	<i>Acanthurus olivaceus</i>	30 all sizes Nihoa 12 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
Goldring bristletooth	<i>Ctenochaetus strigosus</i>	30 all sizes Nihoa 15 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
<b>Family Chaetodontidae</b>		
Oval butterflyfish	<i>Chaetodon lunulatus</i>	30 all sizes Nihoa 26 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
Milletseed butterflyfish	<i>Chaetodon miliaris</i>	30 all sizes Nihoa 30 all sizes Gardner Pinnacles
Blueline butterflyfish	<i>Chaetodon fremblii</i>	30 all sizes Nihoa 20 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
Pebbled butterflyfish	<i>Chaetodon multicinctus</i>	30 all sizes Nihoa 30 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
<b>Family Labridae</b>		
Ornate wrasse	<i>Halichoeres ornatissimus</i>	30 all sizes Nihoa 8 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
Yellowtail coris	<i>Coris gaimard</i>	30 all sizes Nihoa 17 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
Slow wrasse	<i>Coris venusta</i>	30 all sizes Nihoa 16 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles
<b>Family Blenniidae</b>		
Scarface blenny	<i>Cirripectes vanderbilti</i>	15 all sizes Nihoa 15 all sizes French Frigate Shoals 15 all sizes Gardner Pinnacles
Fangblenny	<i>Plagiotremus goslinei</i>	15 all sizes Nihoa

Fangblenny *Plagiotremus ewaensis*

15 all sizes French Frigate Shoals  
15 all sizes Gardner Pinnacles

**Family Lutjanidae**

Blueline snapper (ta'ape) *Lutjanus kasmira*

15 all sizes Nihoa  
15 all sizes French Frigate Shoals  
15 all sizes Gardner Pinnacles

30 all sizes Nihoa  
6 all sizes French Frigate Shoals  
30 all sizes Gardner Pinnacles